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Desiccation Shrinkage and Leaching Vugs in the Calcari grigi Infraliassic Tidal Flat (S. Massenza and Loppio, Trento, Italy)

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ABSTRACT

Cavities in the "Calcari grigi" lower member show various morphologies. By the lining of their walls and bulk textural and structural features, we relate smooth-rim vugs chiefly to desiccation shrinkage processes; complex branching and minutely irregular-rim vugs to desiccation shrinkage followed by leaching, or solely to leaching. Joined shrinkage and leaching processes are the most frequent.

RIASSUNTO

Le cavità del membro inferiore dei «Calcari grigi» hanno varie morfologie. In base all'andamento dei loro margini ed ai caratteri strutturali e tessiturali d'insieme riferiamo le cavità a margini lisci o poco irregolari a preponderanti azioni di disseccamento; quelle a margini minutamente irregolari ad un disseccamento iniziale più dissoluzione chimica o alla sola dissoluzione chimica. L'azione combinata disseccamento più dissoluzione chimica è la più frequente.

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Introduction

The lower member (? upper Retic-lower Liassic) of the "Calcari grigi" formation at S. Massenza and Loppio (Fig. 1) is formed by a cyclic sequence of tidal flat deposits (CASTELLARIN 1972, BOSELLINI and BROGLIO LORIGA 1972). In each complete cycle (Fig. 2) we denominate intervals I–IV respectively: I. The calcareous-clayey deposits of the basal unconformity (emersion). II, IV. The laminated transgressive and regressive wackestones (inter-, supratidal). III. The massive wackestones (subtidal). They correspond to the A, B, C members (FISCHER 1966) and to the basal, lower and upper intertidal, subtidal units (BOSELLINI 1967) of alpine triassic cyclothems. The present paper deals with penecontemporaneous vugs of the intervals II, III, IV. It does not include several other types of cavities occurring in deposits of carbonatic shelf (D'ARGENIO 1966, CHOQUETTE and PRAY 1970).

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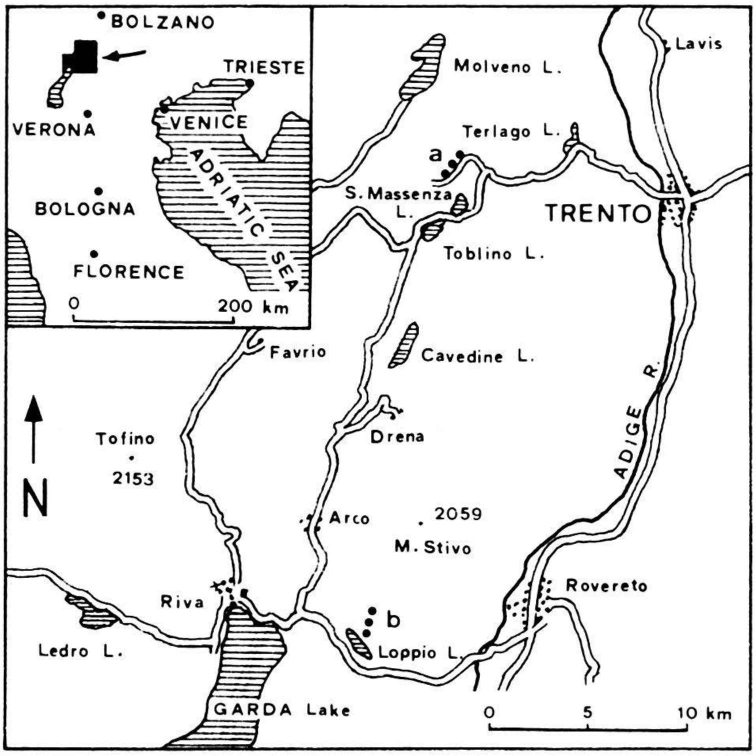

Fig. 1. Positions of the sections (points) at S. Massenza (a) and Loppio (b).

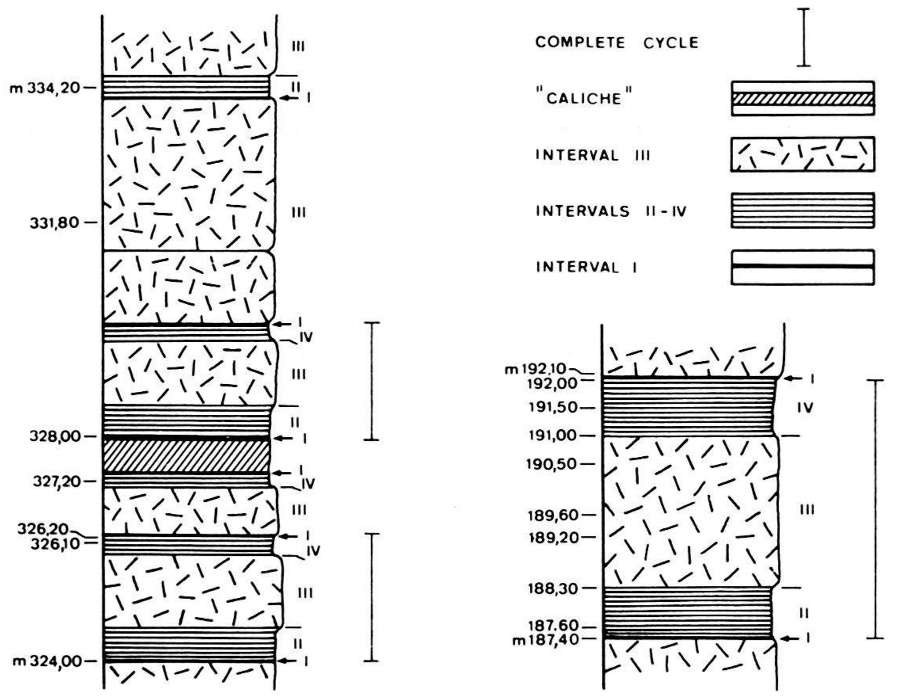

Fig. 2. Interval sequences of some carbonate cycles at S. Massenza ("Calcari grigi", lower member). Samples (left side of the logs) are indicated by distance (given in meters) from the bottom of the cyclothematic member.

Morphology of vugs

Intervals II, IV

The cavities have been subdivided according to their morphology into the following main types (Pl. I).

a) *Laminar vugs* are structures elongated and subparallel to the bedding, often arranged on the same horizontal plane. Synonyms (at least p.p.): shrinkage vugs (THOMAS 1962), sheet cracks (FISCHER 1966), "cavità trapezomorfe" (D'ARGENIO 1966), "cavità inter-" (WOLF 1965) and "intra-biolititiche" (D'ARGENIO 1966), planar vugs (SHINN 1968), etc.

b) *Transversal and oblique vugs* are morphologically just like the foregoing structures, but they elongate normally or obliquely to the bedding. Synonyms (at least p.p.): prism cracks (FISCHER 1966), "cavità prismatiche" (D'ARGENIO 1966), mud-cracks (BOSELLINI 1967), etc.

c) *Globular vugs* are structures, generally small-sized, egg-shaped or globular outlined. Synonyms (at least p.p.): shrinkage vugs (THOMAS 1962), shrinkage pores (FISCHER 1966), "cavità condromorfe" (D'ARGENIO 1966), bubblelike vugs (SHINN 1968), keystone vugs (DUNHAM 1970), etc.
Generic synonyms covering a, b, c types are: false algal structures and burrowlike markings (CLOUD 1962), birdseyes (several authors), (?) dismicrites (FOLK 1959, 1962), fenestra (TEBBUT et al. 1965).

d) *Irregular vugs* are structures without any preferential orientation; they may be independent or may result from coalescence of the a, b, c types. Synonyms: most of the terms quoted in a, b, c vugs, "cavità da soluzione ed erosione interna" and "da processi di tipo microcarsico" (BOSELLINI 1965), "cavità carsico marine" p.p. (D'ARGENIO 1966), etc.

In the considered intervals, the rims of the a–d cavities can be:

1. Nearly smooth without branching.
2. Finely irregular, often branching with very complex patterns.

Interval III

The shapes of the cavities fall within the types already described although forms similar to the *irregular vugs* are largely prevailing. The rims are minutely irregular and widely branching. In this interval the cavities are not as frequent as in the other ones, on the contrary their sizes are quite larger.

Origin of vugs

Intervals II, IV

In these laminated wackestones many laminar vugs are organogenic (inter-, intra-biolititic cavities), as most are originated from algal mats. Nevertheless the vug shapes are frequently modified because of prevailing combined physical-biogenic or purely physical-chemical actions.

The main abiologic factors are desiccation shrinkage (FISCHER 1966, SHINN 1968) and leaching. In our opinion the origin of these cavities may be detected on the ground of the smooth or fine wrinkled and branched features of the walls. A less valuable criterion seems to be the one based upon differences in shape and orientation. Therefore smooth-rim vugs would have been produced by desiccation shrinkage, joined or not by escaping of gas-bubbles (also independent from these *phenomena*, i.e.: gas of bacterial origin, cf. CLOUD 1962). Irregular-rim vugs would result instead: 1. Purely from leaching. 2. From an initial shrinkage followed by leaching. This last composite origin, sometimes with mechanical internal erosion, would be the most frequent.

A pure shrinkage hypothesis in smooth-rim cavities agrees with the lack of internal deposits of vadose calcilutites[3]), with actualistic (cf. CLOUD 1962, Fig. 42) and experimental (SHINN 1968, Fig. 7) evidences.

Relationships between cavities and other structures may well emphasize leaching in irregular-rim vugs. Cavities are in fact included within deposits strongly modified by diagenetical processes and recrystallization, both revealed by an high frequence of: 1. Vadose pisolites (DUNHAM 1969b) contourning the vugs (Fig. 1, 2, Pl. II). 2. "Caliche" deposits (sensu BERNOULLI and WAGNER 1971). 3. Linings of stalactitic cements sometimes joined to real micro-stalactites (Fig. 3, Pl. II). 4. Reversed graded bedding structures (DUNHAM 1969b) in some cases marked by secondary bedding joints. 5. Internal mechanical deposits partly or wholly related to vadose calcilutites (Fig. 5, 6, 7, Pl. I).

Concluding, in these micritic intervals, cavities would be derived from: algal mat activity, pure shrinkage, shrinkage and leaching, pure leaching[4]). In a sediment poor or lacking in micrite a shrinkage origin is much less tenable. Mud-washed deposits (i.e. of a beach) include inter- and intra-granular cavities together with other ones having various shapes. They result mainly from leaching, but sometimes (globular-like vugs) they may be tracks of air-bubbles trapped within the sediment (DUNHAM 1970), or gas-bubbles developped inside it.

Interval III

In the vugs from this interval, mechanical (mainly vadose) and chemical internal deposits and all other joined features may be related chiefly to leaching. In many cases, however, such a process can set up on structures already formed by other causes. Consequently the criterion of subdividing vugs into lithological intervals should be adopted in a broad sense. In fact subtidal deposits may have undergone diagenetical processes in an inter- or supratidal environment. For instance some oolitic packstones contain more or less dissolved oolites. Here the outer envelope, micritized, has not been corroded, while the inner ones (except the *nuclei* of pellets or peloids) have undergone partial or total leaching. Oomoldic vugs are filled by intragranular secondary calcilutites (bottom) which formed in situ as undissolved carbonate residues of leaching (Fig. 4–8, Pl. II) and by cement (top).

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[3]) Forming by selective chemical dissolution or precipitation and mechanical processes in a vadose environment (cf. "diagenetic silt" of DUNHAM 1969a, p. 166–168).

[4]) Leaching can be also accompanied by internal mechanical erosions.

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Plate I

Vugs in the "Calcari grigi", lower member (S.Massenza and Loppio sections). Laminar (Fig. 1, 5, 6, 4 bottom), globular (Fig. 2, 3, 4 top), irregular (Fig. 7) vugs. They result from: desiccation shrinkage (1, 2, 3), shrinkage and slight leaching (4), leaching possibly on initial shrinkage (5, 6), prevailing leaching (7). Figures 5, 6, 7 show vadose calcilutite deposits (exclusive in Fig. 5, 6). Enlargements are indicated by scales.

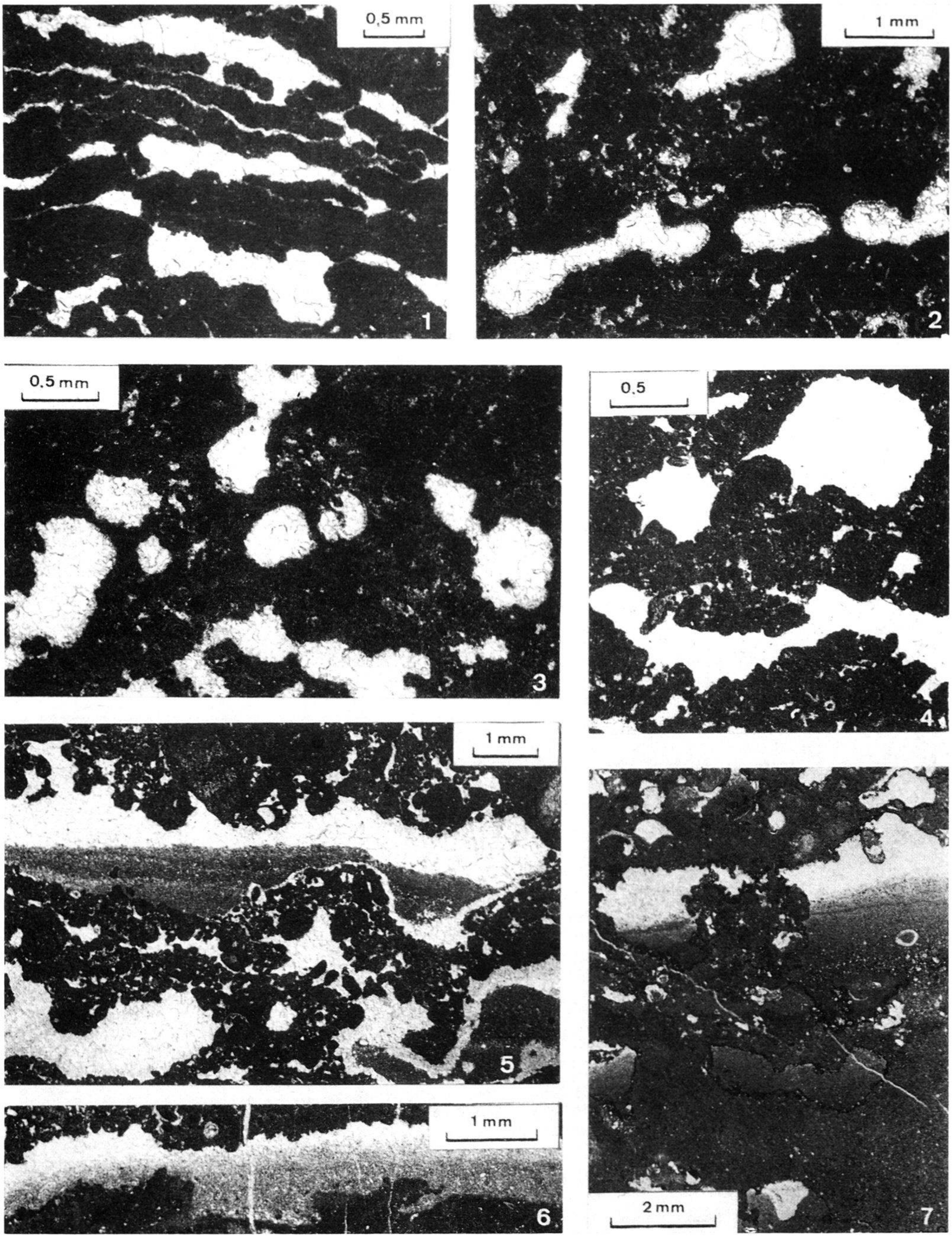
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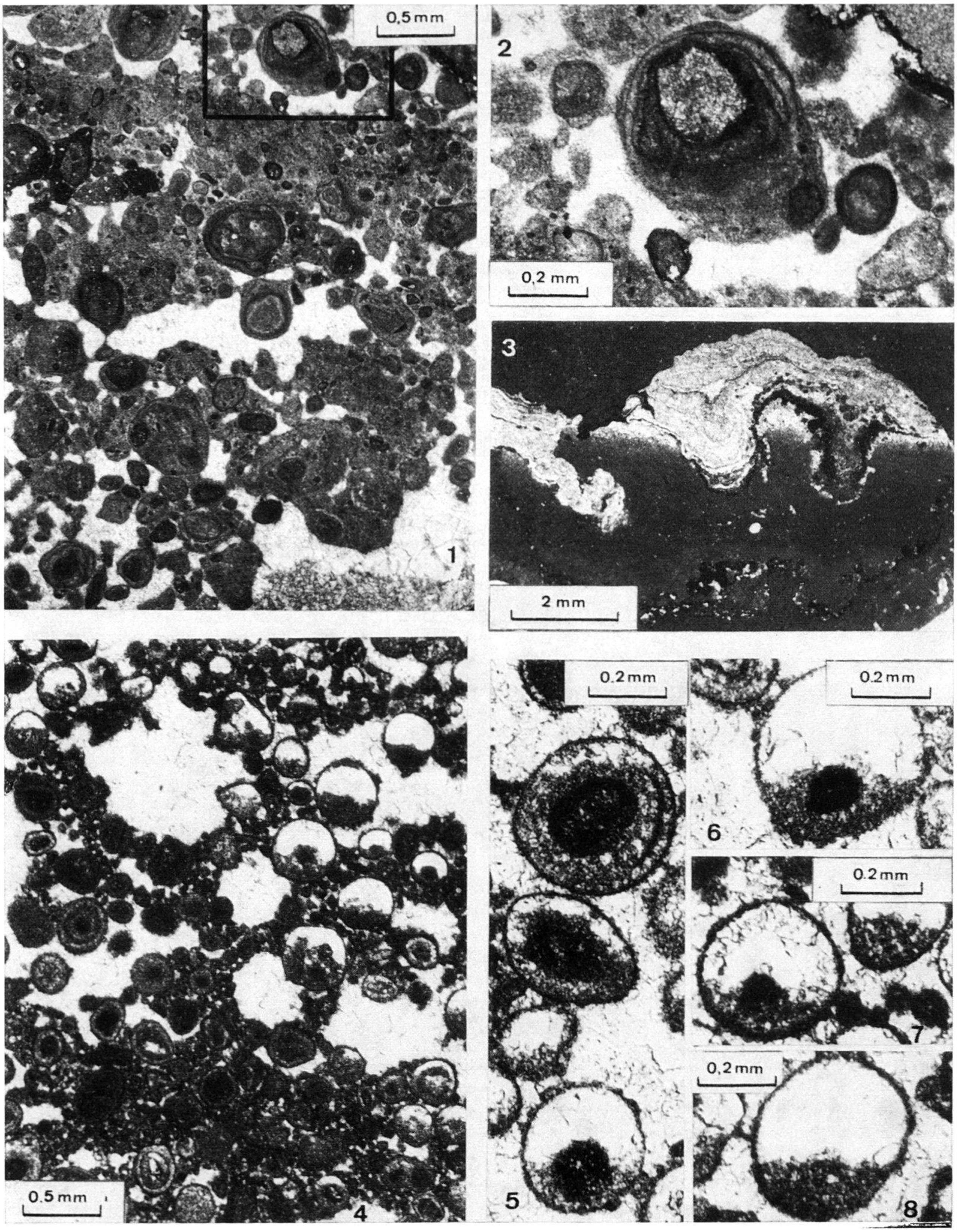
Plate II

Vugs in the "Calcari grigi", lower member (S. Massenza and Loppio sections). Irregular vugs (Fig. 1, 2, 3) contourned by vadose pisolites (1, 2). Figure 3 shows stalactitic crusts. Figures 4–8 illustrate dissolution in oolites with intragranular residual deposits and undissolved *nuclei*. Enlargements are indicated by scales.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